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TWO METHODS OF ESTIMATING THE GROWTH
OF CRIMINALITY IN THE UNITED STATES.BY LOUIS NEWTON ROBINSON, *Professor of Economics, Swarthmore College.*

My attention was drawn some time ago to a method* which Roland P. Falkner, in one of his excellent articles on criminal statistics, works out from the census figures for estimating the number of people who were committed to prison during a given year. It must be remembered that prior to the year 1904, the census concerned itself, with some unimportant exceptions, to the number of prisoners found in confinement on a certain day of the year. As Dr. Falkner pointed out, no real indication of the growth of criminality could be obtained from these figures. If, however, the number of those who were committed during the various census years were known, some important deductions might be made from the figures. On account of certain rather obvious defects in the method, Dr. Falkner put no great emphasis on the conclusion which he was able to draw from a comparison of the commitments of two succeeding census years. His work, however, was extremely valuable since it threw much light on the nature of the federal criminal statistics which have been grossly misunderstood.

It has seemed to me, on thinking it over, that it was possible to devise a method for estimating the number of prisoners committed to prison during a census year which would be superior to Dr. Falkner's method in so far that it would allow for an increase of population—a thing which Dr. Falkner's method did not do. And secondly, it seemed possible to construct, with the aid of data which Dr. Falkner did not have at hand at the time he wrote, an entirely new method of judging the increase or decrease of criminality during the past few years.

Since a study of Dr. Falkner's method led to my own solution of the difficulty, and since his work lays bare the mean-

*Crime and the Census by Roland P. Falkner, in *Annals of the American Academy*, 1897, Vol. IX, pp. 42-69.

ing of the federal criminal statistics, I can do no better than begin with a summary of his scheme.

By a simple illustration he shows that the number of prisoners found in prison on a certain day of the year may bear no relation to the number of crimes committed during that year. This is his illustration:

"It is clear that the number of prisoners at any time depends not only upon the number who have been sent to prison, but also upon the length of the sentences which have been imposed upon them. This is seen very clearly by an extreme case. If in the town A, a man is sent to prison every day with a sentence of one year's imprisonment, the prison will, at the end of the year, contain 365 prisoners. If now, in town B, a prisoner is received at the prison daily, with but the short sentence of a single day, there will be, at the end of the year, one prisoner. The number of offences has been the same, yet the population of the two prisons gives no clue to this fact." *

He then proceeds to work out his method from a hypothetical case, made up of data similar to those which could be had from the census volumes.

His hypothetical case is as follows: Suppose that in one year ten prisoners were sent to prison, each with a sentence of one year. Suppose, also, that in the same year ten prisoners were sent to prison, each with a sentence of six months. At the end of the year, the number of those remaining in prison would be all of those with the one year sentence and half of those with the six-month sentence, *viz.*, fifteen.

Thus:

	Sent to Prison Annually.	Sentence.	Remaining in Prison.
Class A	10	1 year	10
Class B	10	6 months	5
	20		15

From this, he concludes that if one has the last two columns given, one can obtain the first column, or the number of each class sent to prison annually. The problem is simple.

Divide the number of each class found in prison by the length of their respective sentence, and we have

$$10 \div 1 = 10 \text{ Class A}$$

$$5 \div .5 = 10 \text{ Class B}$$

The defect of this scheme is, of course, that it depends for its validity on conditions which are somewhat improbable. Dr. Falkner recognizes this, for he says:

“Of course such a calculation proceeds upon the assumption that the total number of prisoners does not essentially vary and that men are sentenced to prison for each term at a given yearly rate. For long sentences especially, such a supposition is manifestly incorrect. As the population grows, the number of prisoners grows with it, and may indeed grow in excess of it. The number received at each rate of sentence is constantly growing. We know no method by which allowance can be made for such an increase.”*

I propose to show now that an allowance for this increase in commitments, occasioned by the gradual increase in population, can be made.

Assume that on June 1, 1870, the population of a given country was 10,000,000 which increased by arithmetical progression until on June 1, 1890, it stood at 20,000,000. Imagine, also, that in the year just prior to June 1, 1871, one hundred and five people had been committed to prison, each with a sentence of twenty years. Now let the *ratio* of yearly commitments to population remain the same throughout the period, *i. e.*, one commitment to each 100,000 of population.

The number of those with a sentence of twenty years who would be found in the prisons of this country on June 1, 1890, would evidently be the sum of all who had been committed during this period, namely, 3050. This figure corresponds exactly to the data yielded by the census volumes of the United States.

*Pp. 55-56.

Year.	Population.	No. of prisoners with a 20-year sentence committed during preceding year.
June 1, 1870.	10,000,000	0
June 1, 1871.	10,500,000	105
June 1, 1872.	11,000,000	110
June 1, 1873.	11,500,000	115
June 1, 1874.	12,000,000	120
June 1, 1875.	12,500,000	125
June 1, 1876.	13,000,000	130
June 1, 1877.	13,500,000	135
June 1, 1878.	14,000,000	140
June 1, 1879.	14,500,000	145
June 1, 1880.	15,000,000	150
June 1, 1881.	15,500,000	155
June 1, 1882.	16,000,000	160
June 1, 1883.	16,500,000	165
June 1, 1884.	17,000,000	170
June 1, 1885.	17,500,000	175
June 1, 1886.	18,000,000	180
June 1, 1887.	18,500,000	185
June 1, 1888.	19,000,000	190
June 1, 1889.	19,500,000	195
June 1, 1890.	20,000,000	200
		—
		3050

By referring to the table, it will be seen that, as the population increased in arithmetical progression from 1870 to 1890, and as the prison commitments bore a constant ratio to this population, the prison commitments increased also in arithmetical progression. This means that the number 3050 is the sum of an arithmetical progression whose number of terms is twenty and whose common difference is five.

Now the problem is simply this: Given the number of those found in prison on June 1, 1890, who had received a twenty-year sentence, is it possible without having any further facts regarding the commitments but knowing the population of the country in 1870 and 1890, to recreate the column of figures of which 3050 is the sum. If it is, then some improvement

has been made in Dr. Falkner's method, since allowance for the increase in population is thereby made.

Here is an equation in arithmetical progression:

$$S = \frac{n}{2} [2a + (n-1) d]$$

If now any three of the letters are given, the fourth may easily be found. Which are given in the problem set?

$$S = 3050$$

$$n = 20$$

But a is not given, nor is d ; and to solve the equation one of these letters must be had. However, if d can be stated in terms of a there is only one unknown letter in the equation and it can be solved.

In the table, it can be observed that the ratio of the difference between the population of 1872 and 1871 to the population of 1871 is as 1 is to 21; also that the ratio of the difference between the commitments of 1872 and of 1871 to the number of commitments in 1871 is as 1 is to 21. In short, the per cent. of increase in commitments is always the same as the per cent. of increase in population of the corresponding year. Since d can be stated as a certain per cent. of a , and as it is possible to determine what this per cent. is by reference to the population figures, the equation can be stated with only one unknown quantity in it, thus:

$$S = \frac{n}{2} [2a + (n-1)\% a]$$

To determine what per cent. of a it is, one can proceed as follows:

Year.	Population.
1890	20,000,000
1870	10,000,000
20	10,000,000

$$10,000,000 \div 20 = 500,000$$

Then, assuming as this method does, that the population increased in arithmetical progression,* the population in 1871

* If the population increased by geometrical progression, my method would, of course, be based on the rules of geometrical progression.

would be 10,500,000, and in 1872 it would be 11,000,000. The ratio of the increase in population between the years 1871 and 1872 to the population of 1871 is 1 to 21. Recalling the fact that the ratio of the increase in commitments between the years 1871 and 1872 to the commitments of 1871 must be the same, it is possible by substitution to derive the following equation from the preceding one, thus:

$$S = \frac{n}{2} [2a + (n-1) \frac{1}{21} a]$$

$$\text{or} \\ 3050 = \frac{20}{2} [2a + (20-1) \frac{1}{21} a]$$

$$= 10 (2a + \frac{19}{21} a)$$

$$= 20 a + \frac{190}{21} a$$

$$= 29 \frac{1}{21} a$$

$$105 = a$$

$$\text{Since } d = \frac{1}{21} a$$

$$d = 5$$

The problem has been solved, since it is possible with the aid of a and d to find any numbers in the column of figures whose sum is denoted in the table by 3050.

An application of the two methods to a concrete problem will serve, perhaps, to emphasize the difference between this new method and that of Dr. Falkner.

The number of prisoners with a sentence of twenty years or more reported in prisons on June 1, 1890, was 1697. Following the Falkner method: $1697 \div 20 = 84.85$ is the estimated number of those who were committed during the year just preceding June 1, 1890.

My scheme is as follows:

Year.	Population.
1890	62,947,714
1870	38,558,371
	20) 24,389,343
	1,219,467.15

Year.	Population.
1870	38,558,371
1871	39,777,838
1872	40,997,305

$$40,997,305 - 39,777,838 = 1,219,467$$

$$1,219,467 \div 39,777,838 = .03065$$

By substitution:

$$S = 1,697$$

$$n = 20$$

$$d = .03065a$$

$$\begin{aligned} \therefore 1,697 &= \frac{20}{2}[2a + (20-1) .03065a] \\ &= 10[2a + (19) .03065a] \\ &= 10(2a + .58235a) \\ &= 10(2.58535a) \\ &= 25.8235a \end{aligned}$$

$$65.71 = a$$

$$\therefore d = .03065 \times 65.71 = 2.014$$

$$\begin{aligned} 1 &= a + (n-1)d \\ &= 65.71 + 19 \times 2.014 \\ &= 65.71 + 38.26 \\ &= 103.97 \end{aligned}$$

103.97 is, then, the number, estimated by my method, of those having a sentence of twenty years, who were committed to the prisons during the year just preceding June 1, 1890. The following table will show how the 1697 prisoners are distributed back through the preceding twenty years by both methods.

Since my method makes allowance for the increase in population, it seems more reasonable to suppose that 103.966 rather than 84.85 was the number of those having a sentence of twenty years who were committed to prison during the year just preceding June 1, 1890. This, then, constitutes the first of the two methods which I have set out to present. It makes possible a comparison, rough it is true, but useful, perhaps, of the commitments of one census year with those of another.

Year.	Dr. Falkner's Method.	New Method.
1871	84.85	65.71
1872	84.85	67.724
1873	84.85	69.738
1874	84.85	71.752
1875	84.85	73.766
1876	84.85	75.780
1877	84.85	77.794
1878	84.85	79.808
1879	84.85	81.812
1880	84.85	83.826
1881	84.85	85.840
1882	84.85	87.854
1883	84.85	89.868
1884	84.85	91.882
1885	84.85	93.896
1886	84.85	95.910
1887	84.85	97.924
1888	84.85	99.938
1889	84.85	101.952
1890	84.85	103.966
Total	1697.00	1697.000

After the census of 1890, fourteen years passed before a new enumeration of prisoners took place. Thanks to Dr. Falkner himself, the scope of its inquiry was broader than that of the preceding one. Not only was the number of those found in prison on a certain day of the year recorded, but also the number of those who had been committed during the year.

The report containing the results of this investigation includes, therefore, two sets of data: (a) the number of prisoners found in prison June 30, 1904, and (b) the number of prisoners committed to penal institutions during the year 1904.

Do these two kinds of information offer any additional basis for a statistical calculation of the increase or decrease of criminality in the United States? It seems to me that they do.

In thinking over the question of criminality in the United States, it is possible to suppose some five different conditions of affairs, thus:

1. It is increasing exactly in proportion to the population.
2. It is increasing faster than the population.
3. It is increasing slower than the population.
4. The total amount is decreasing, regardless of the increase in population.
5. It is increasing or decreasing by leaps and bounds, neither increasing gradually nor decreasing gradually, but changing back and forth with great rapidity from year to year.

These five forms seem to include all possible conceptions of what the actuality may be. Considering them in reverse order No. 5 presupposes a state of affairs which all statistical studies show to be impossible, in view of the great stability of the social mass as a whole, where abrupt changes are not found.

No. 4 seems also incredible. Not even the most optimistic student of social affairs thinks this to be possible.

Nos. 3, 2, and 1 all seem to be possible conceptions of the real situation.

If one looks carefully at conceptions 1, 2, and 3, he will see that No. 2 lies on one side of No. 1, and that No. 3 lies on the other side of No. 1. Hence it is that, if one can secure a set of figures which represent condition No. 1, and has given to him another set which might represent either condition No. 1, 2 or 3, he can say at once whether this second set portrays condition No. 1, 2 or 3.

It has been generally understood that during the last part of the nineteenth century the population of the United States has been increasing in arithmetical progression. Now if it has, and if criminality has been increasing in exact proportion to population, then criminality also has been increasing in arithmetical progression. This has already been shown above to be true. Therefore, if condition No. 1 represents the situation faithfully, the number in each group of prisoners classified by length of sentence is the sum of an arithmetical progression whose number of terms is represented by the length of sentence, and whose last term can be found by the method already discussed. Here, then, is the second method which I propose. It is possible to name with a fair degree of exactness the number of people, say with a twenty-year sentence, who

would have been committed during the year if criminality had been increasing in exact proportion to population. And since this is possible and since the number of those who actually were committed with a twenty-year sentence is given, one can say which of the three conceptions is the true one.

In applying the second method to a concrete case, a slight, though not serious, complication arises from the fact that the number of those committed is given for the calendar year 1904 and not for the year preceding June 30, 1904, this being the date on which those in prison were enumerated.

On page 97 of the report for 1904, it is stated that 1405 prisoners, each with a sentence of twenty years, were found in prison on June 30, 1904; also on page 129 that the number of such who had been committed during the calendar year 1904 was 209.

To make all possible allowance for good behavior, pardons and deaths, the 1405 prisoners may be considered as the toll of fifteen instead of twenty years.

To proceed:

Population.	Year.
75,994,575	1900
62,947,714	1890
13,046,861	10

$13,046,861 \div 120 = 108,724$ or the monthly difference.

Population.	Year.	Month.
61,648,028	1889	June 1
61,751,752	1889	July 1 *
61,860,476	1889	Aug. 1

$$61,860,476 - 61,751,752 = 108,724$$

$$108,724 \div 61,751,752 = .0017609$$

$$S = \frac{n}{2} [2a + (n - 1) d]$$

$$S = 1405$$

$$n = 180 (i. e., 15 \text{ yrs.} \times 12 \text{ mo.})$$

$$d = .0017609a$$

* To avoid undue mathematical process, I have treated July 1 as the equivalent of June 30, in all that follows.

By substitution

$$\begin{aligned} 1405 &= \frac{180}{2} [2a + (180-1).0017609a] \\ &= 90 (2a + .3152011a) \\ &= 90 (2.3152011a) \\ &= 208.368099a \end{aligned}$$

$$6.742 = a$$

$$\begin{aligned} d &= .0017609 \times 6.742 \\ &= .0118719 \end{aligned}$$

$$\begin{aligned} 1 &= a + (n-1)d \\ &= 6.741 + (179 \times .0118719) \\ &= 8.866 \text{ or the number that would} \end{aligned}$$

have been committed during the month preceding July 1, 1904, if criminality had increased in exact proportion to population.

February	1,	1904	8.8070
March	1,	1904	8.8188
April	1,	1904	8.8306
May	1,	1904	8.8424
June	1,	1904	8.8542
<i>July</i>	<i>1,</i>	<i>1904</i>	<i>8.866</i>
August	1,	1904	8.8778
September	1,	1904	8.8896
October	1,	1904	8.9014
November	1,	1904	8.9132
December	1,	1904	8.9250
January	1,	1905	8.9368
Year		1904	106.4628

If, then, criminality had increased in proportion to population, there would have been committed to prison during the calendar year 1904, 106 people. But the report states that during this year 209 were committed. The difference between the two numbers is so great, and since I made ample allowance at the beginning for good behavior, pardons and deaths, I feel that the only conclusion to be made is that crimes for which a twenty-year sentence would be given have increased faster than the population.

The method is, of course, applicable to all groups of crimes as differentiated by the length of sentence.